CLAIMS

1. A shuttle for synchronizing a reference clock with downhole clock positioned within a borehole, said shuttle comprising:

(a) a shuttle clock; and

(b) a data port operationally connected to said shuttle clock; wherein

(c) said shuttle clock is synchronized with said reference clock via a first transmission link provided by said data port;

(d) said shuttle is conveyed along said borehole to said downhole clock by pumped drilling fluid; and

(e) said downhole clock is synchronized with said shuttle clock via a second transmission link provided by said data port thereby providing synchronization of said downhole clock with said reference clock.

2. The shuttle of claim 1 wherein said data port comprises a short range radio frequency transmitter and a radio frequency receiver and an antenna operationally connected to said transmitter and said receiver.

3. The shuttle of claim 1 wherein said data port comprises a wet connector.

4. The shuttle of claim 1 further comprising a pressure housing in which said shuttle clock and said data port are incorporated, wherein said pressure housing is deformed thereby allowing disposal of said shuttle within said borehole after said downhole clock is synchronized with said shuttle clock via said second transmission link.

5. The shuttle of claim 1 further comprising a pressure housing in which said shuttle clock and said transmitter-receiver are incorporated, wherein said pressure housing is retained downhole after said downhole clock is synchronized with said shuttle clock via said second transmission link thereby allowing said shuttle to be subsequently retrieved.

6. The shuttle of claim 1 wherein said downhole clock is incorporated within a seismic-while-drilling system.

7. The shuttle of claim 1 wherein said downhole clock is incorporated within a nuclear spectroscopy logging -while-drilling system.

8. The shuttle of claim 1 wherein said downhole clock is incorporated within a pulsed neutron logging -while-drilling system.

9. A method for synchronizing a reference clock and a downhole clock positioned within a borehole with, the method comprising:

(a) providing a shuttle comprising

(i) a shuttle clock, and

(ii) a data port operationally connected to said shuttle clock;

(b) synchronizing said shuttle clock with said reference clock via a first transmission link provided by said data port;

(c) conveying said shuttle along said borehole to said downhole clock by pumped drilling fluid; and

(d) synchronizing said downhole clock with said shuttle clock via a second transmission link provided by said data port thereby providing synchronization of said downhole clock with said reference clock.

10. The method of claim 9 wherein said data port comprises a short range radio frequency transmitter and a radio frequency receiver and an antenna operationally connected to said transmitter and said receiver.

11. The method of claim 9 wherein said data port comprises a wet connector.

12. The method of claim 9 comprising the additional steps of:

(a) providing a pressure housing suitable for disposal;

(b) incorporating said shuttle clock and said data port within said pressure housing;

(c) synchronizing said downhole clock with said shuttle clock via said second transmission link; and

(d) subsequently disposing of said shuttle within said borehole.

13. The method of claim 9 comprising the additional steps of:

(a) incorporating said shuttle clock and said data port within said pressure housing;

(b) synchronizing said downhole clock with said shuttle clock via said second transmission link; and

(c) retaining said pressure housing downhole after said downhole clock is synchronized with said shuttle clock via said second transmission link thereby allowing said shuttle to be subsequently retrieved.

14. The method of claim 9 wherein said downhole clock is incorporated within a seismic-while-drilling system.

15. The method of claim 9 wherein said downhole clock is incorporated within a nuclear spectroscopy logging -while-drilling system.

16. The method of claim 9 wherein said downhole clock is incorporated within a pulsed neutron logging -while-drilling system.

17. A measurement system for determining a geophysical parameter in the vicinity of a borehole, the system comprising:

(a) surface equipment comprising a reference clock;

(b) at least one shuttle comprising a shuttle clock and a data port; and

(c) a borehole assembly comprising at least one sensor and a downhole clock; wherein

(d) a synchronization procedure synchronizes said downhole clock with said reference clock by

(i) synchronizing said shuttle clock with said reference clock via said data port,

(ii) subsequently launching at least one said shuttle into a first end of a drill string,

(iii) conveying said at least one shuttle by means of pumped drilling fluid to said borehole assembly which terminates a second end of said drill string,

(iv) synchronizing said downhole clock with said shuttle clock via said data port to obtain said reference clock and downhole clock synchronization; and

(d) outputs from said reference clock and from said downhole clock and from said at least one sensor are combined to determine said geophysical parameter.

18. The measurement system of claim 17 wherein one said shuttle is launched at time interval required to maintain said reference clock and shuttle clock synchronization within a predetermined limit.

19. The measurement system of claim 17 comprising a plurality of said shuttles wherein each shuttle of said plurality of shuttles is launched sequentially at time intervals required to maintain said reference clock and shuttle clock synchronization within a predetermined limit.

20. The system of claim 18 further comprising a telemetry system linking said borehole assembly to said surface equipment, wherein durations of said time interval is determined using information telemetered from said borehole assembly to said surface equipment via said telemetry system.

21. The measurement system of claim 17 wherein said data port comprises a short range radio frequency transmitter and a radio frequency receiver and an antenna operationally connected to said transmitter and said receiver.

22. The measurement system of claim 17 wherein said data port comprises a wet connector.

23. The measurement system of claim 17 wherein said at least one sensor comprises a seismic sensor.

24. The measurement system of claim 17 wherein each said shuttle further comprises a pressure housing in which said shuttle clock and said data port are incorporated, wherein said pressure housing is deformed thereby allowing disposal of said shuttle within said borehole after synchronizing said downhole clock with said shuttle clock via said data port to obtain said reference clock and downhole clock synchronization.

25. The measurement system of claim 17 wherein each said shuttle further comprises a pressure housing in which said shuttle clock and said data port are incorporated, wherein said pressure housing is retained downhole after synchronizing said downhole clock with said shuttle clock via said data port to obtain said reference clock and downhole clock synchronization.

26. A method for determining a geophysical parameter in the vicinity of a borehole, the system comprising:

(a) providing surface equipment comprising a reference clock;

(b) providing at least one shuttle comprising a shuttle clock and a data port;

(c) providing a borehole assembly comprising at least one sensor and a downhole clock;

(d) synchronizing said downhole clock with said reference clock by

(i) synchronizing said shuttle clock with said reference clock via said data port,

(ii) subsequently launching at least one said shuttle into a first end of a drill string,

(iii) conveying said at least one shuttle by means of pumped drilling fluid to said borehole assembly which terminates a second end of said drill string,

(iv) synchronizing said downhole clock with said shuttle clock via said data port to obtain said reference clock and downhole clock synchronization to within a predetermined limit; and

(d) combining outputs from said reference clock and from said downhole clock and from said at least one sensor to determine said geophysical parameter.

27. The method of claim 26 wherein a shuttle is launched at time interval required to maintain said reference clock and shuttle clock synchronization within a predetermined limit.

28. The method of claim 26 comprising the additional steps of:

(a) providing a plurality of said shuttles; and

(b) launching each shuttle of said plurality of shuttles sequentially at time intervals required to maintain said reference clock and shuttle clock synchronization within a predetermined limit.

29. The method of claim 28 further comprising the additional steps of:

(a) linking said borehole assembly to said surface equipment with a telemetry system; and

(b) determining durations of said time intervals using information telemetered from said borehole assembly to said surface equipment via said telemetry system.

30. The method of claim 26 wherein said data port comprises a short range radio frequency transmitter and a radio frequency receiver and an antenna operationally connected to said transmitter and said receiver.

31. The method of claim 26 wherein said data port comprises a wet connector.

32. The method of claim 26 wherein said at least one sensor comprises a seismic sensor.

33. The method of claim 26 comprising the additional steps of:

(a) providing a pressure housing for each said shuttle in which said shuttle clock and said data port are incorporated; and

(b) deforming each said pressure housing thereby allowing disposal of said shuttle within said borehole after synchronizing said downhole clock with said shuttle clock via said data port to obtain said reference clock and downhole clock synchronization.

34. The method of claim 26comprising the additional steps of:

(a) providing a pressure housing for each said shuttle in which said shuttle clock and said data port are incorporated; and

(b) retaining each said pressure housing downhole after synchronizing said downhole clock with said shuttle clock via said data port to obtain said reference clock and downhole clock synchronization.

35. The method of claim 26 wherein said predetermined limit is one millisecond or less.